SPOLIATION

OF THE

FALLS OF NIAGARA

By Dr. J. W. SPENCER

Washington, D. C.

Address before the American Association
for the Advancement of Science,
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1. *First Reference to Niagara—Champlain.*—A few weeks hence there will be celebrated the three-hundredth anniversary of the foundation of the city of Quebec, by the Great Champlain. Out of this grew the Dominion of Canada. Although the establishment of the little settlement on the St. Lawrence River made Champlain most famous, it is not in this that his chief greatness lay, but rather in his wonderful explorations in the lake region of the interior of the continent, throughout a long life spent in the wilderness.

Jacques Cartier had ascended the St. Lawrence in 1535 and again a few years later. Champlain followed in his tracks as far up the river as Montreal (in 1603) five years before the settlement of Quebec. From the summit of the old volcanic mountain at Montreal he saw the first or Lachine rapids of the St. Lawrence, above which he could discern the smooth water of the expanded river, now known as Lake St. Louis. Here he received accounts from three different Indians as to the nature of the country beyond. Their communication must have been largely carried on by signs and diagrams, drawn on the sand. Although the first volume of Champlain's works is extremely rare, the accounts were transcribed by Lescarbot in his history of New France, published soon after, in 1609. The description of the rapids and various lake-like expansions of the St. Lawrence, the Thousand Islands, Lake Ontario, the occurrence of Niagara with its rapids, and Lake Erie reaching to Lake Huron "beyond which no man had been," were all so complete that a navigator unimpeded by hostile Indians could easily have found his way. But the natives were hostile, so that Lake Huron came to be known long before Lake Erie and the Niagara River.

2. *First Account of Niagara River.*—Champlain never saw Niagara,

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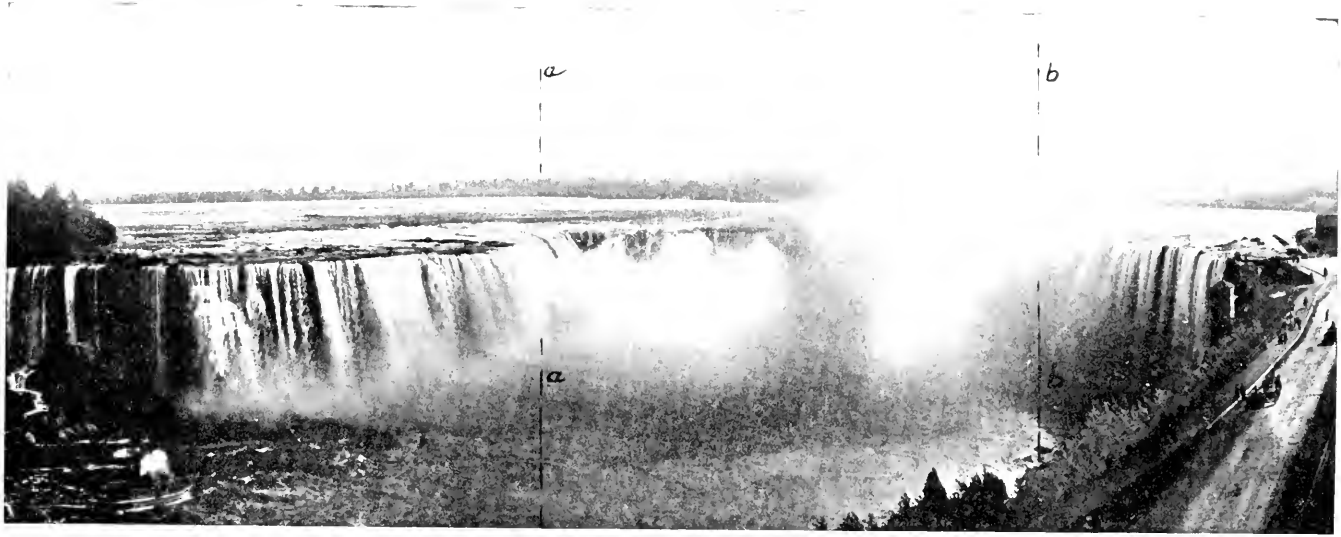

FIG. 1. FALLS OF NIAGARA, CANADIAN BRANCH, 1899. (By permission of Baker Art Gallery, Columbus, Ohio.) Sheet of water to the right of line *bb* (west side) has since been curtailed 415 feet, on account of power diversion. The falls to the left of line *aa* are being drained by the diversion, which, when it reaches the franchise amount, will leave 800 feet of bare rock on the Goat Island or eastern side, thus throwing the remaining falls entirely into Canadian territory.

but on his map of 1632 he represents a long series of rapids, located at the end of Lake Ontario, and says concerning them, "A very high fall of water at the end of the rapids of St. Louis (a name given to Lake Ontario) where many kinds of fish in descending are stunned." That the river was famous among the Indians, on account of the falls, and possibly among a few "*Courreurs de bois*" and missionary priests, is certain, as Father Lalement, who first mentions its name (Onguaahra), speaks of it as "so celebrated." This was in 1641, yet he does not mention the falls. In 1645, Dr. Gendron wrote a letter about the falls, but this was not published until 1660; in the meanwhile (1648) Father Ragueneau mentions them as occurring on Niagara River. This was the beginning of the historic period.

3. *Approaching Peril to Niagara Falls.*—The Falls of Niagara are now entering another and much more critical epoch in their history. The time has not arrived when their use has become a necessity, and even in their spoliation, other and larger interests are at stake. Niagara is a world possession, yet its very existence is imperilled by the greed of a few persons, or for the exigencies of politicians.

4. *Commission for Investigation.*—Extended operations were already at work upon the falls, when Dr. Robert Bell, Canada's most distinguished geologist, at the head of the Geological Survey, commissioned me, three years ago, to make a complete investigation upon the recession of Niagara Falls, so as to record the undisturbed work of nature, and also to determine how far the falls could be diverted without bringing about unforeseen disasters.

5. *Opinions of Power Diversion.*—At that time, in the opinion of some serious observers, the falls were imperilled, and Dr. John Clarke, state geologist of New York, pointed out the impending destruction of the American Falls. There were also many sensational magazine articles, bearing on the same subject, but in these no data were given by which to form judicious opinions. On the other hand, those interested in the diversion of the water insisted that no serious damage would be done. Personally I had no opinion whatever, though I regretted the disfigurement of the falls, through the structures erected by the power companies, one such being placed even beneath the cataract itself, inside the Park Reservation on the Canadian side, especially offensive as seen from the American side (shown in a succeeding plate, figure 8).

6. *International Waterway Commission established for saving the Falls.*—Before this time, the late Honorable Andrew H. Green had secured the passage through Congress of a bill, authorizing the establishment of an International Waterway Commission, his specific object being the preservation of Niagara Falls. Indeed it was for this same object that the International Park at Niagara had been established at an earlier date, largely through the efforts of the Earl of Dufferin,

Governor General of Canada, and Mr. A. H. Green, of New York, who subsequently prevented the intrusion of all power structures in the state reservation on the New York side, a policy unfortunately not followed by the government on the Canadian side. Here even the park was widened, at the cost of the falls, in curtailing their crest-line by several hundred feet. Yet among those interested in the power companies it was commonly said that they were improving the park; a few, who were powerless, seeing through this sophistry. That public opinion was swayed by such representations is not to be wondered at, for at a later date, April 26, 1906, the Canadian section of the commission states that, "It would be a sacrilege to destroy the scenic effect of Niagara Falls, unless and until the public needs are so imperative as to compel and justify the sacrifice" (p. 102), and yet they suggest no curtailment on the Canadian side. The report further says that, "It is possible to preserve the beauty, and yet permit the development on the Canadian side of the Niagara River"—of a certain amount of power on which I shall comment later, but no data are given on which the above statement is based. Indeed, I was unable to form any opinion whatsoever until my own investigations were made, which were begun before the proceedings of the International Commission, and not completed until some time after the premature report, cited above, appeared in print.

7. *Results, the Outcome of Purely Scientific Investigations.*—The conclusions reached concerning the spoliation of the Falls of Niagara are the outcome of investigations into purely scientific problems, and a brief account of them may show more convincingly how these results have been obtained. Just twenty years ago, I had the honor of announcing to this association the discovery that Lake Huron, with Michigan and Superior as tributaries, formerly emptied to the northeast, and did not discharge into a shrunken Lake Erie; and, consequently, Niagara was then a very small river. Six years later, I again laid before this association additional observations indicating that the falls had receded nearly three miles, when the Huron drainage was turned into Lake Erie; and with the fragmentary data bearing on the discharges of the rivers, an attempt was made, with only partial success, to determine the size of the original Niagara River.

One of the chief problems of my latest investigations was to determine the volume of the Niagara River in its early stages. It was not a simple matter, for contradictions appeared in the data obtained, which had to be eliminated. This involved the whole question of the physics of the rivers, requiring months of labor to collect the data and analyze them. In this connection, I found that the outlets of both Lake Erie and Lake Ontario had been recently lowered, while Mr. Thomas Russel, of the U. S. Lake Survey, had previously made the great discovery that

the outlet of Lake Huron had also been lowered. This was the starting-point of the investigation into the spoliation of Niagara. The channel of the river had been deepened just after 1890, owing to natural scour by the currents, the effectiveness of which was increased by the powerful jamming of vast quantities of ice against the barriers at the Upper Rapids, immediately above the falls, and to a small extent by the shifting of the boulders on the river bed just below the outlet of Lake Erie.

8. *Corrections of Discharge Measurements.*—The discharge measurements had been made by the U. S. Lake Survey after the lowering of the lake outlets had occurred, that of the Erie outlet causing the subsidence of the lake level to nearly one foot. As the daily records of the lake fluctuations have been kept for fifty years or more, it was possible to determine the discharges of the rivers throughout that time. Failing to take into consideration this lowering of the lake outlets, the calculations of the river discharges prior to 1891 were excessive, and those of Lakes Huron and Erie showed inadmissible differences; as also found by Mr. Russel. These discoveries reduce the calculated discharge of Niagara River, prior to 1891, by 22,000 cubic feet per second, which would bring its volume from 1860 to 1890 into agreement with the mean measured discharge for the fifteen years from 1891 to 1905, inclusive, or 204,000 cubic feet per second; and the low water discharge has fallen to 160,000 cubic feet. There have been years of high water and others of low, yet by taking groups of years, the mean values are remarkably uniform, but the latter period must not be regarded as one of low water, a fact which I can not too strongly emphasize, although the lake levels have actually been much lower than during the preceding period, due, as just stated, to the lowering of the outlets. Such years, however, as 1901, showed very low water in Lake Erie, and reduced discharge of Niagara River.

9. *Present very High Water.*—In contrast with this, the lake-levels during 1907 were extraordinarily high, increasing even till the present month (June, 1908). Fragmentary information, preserved, indicates that Lakes Erie and Ontario were unusually low in 1819. The fuller record of subsequent years shows that the highest water occurred in 1838, and nothing has been comparable to it until the present high stages. Although these do not make the lakes appear to be now so high as seventy years ago, this is because of the lowering of their outlets and the further diversion of water for power purposes, both of which, if allowed for, would bring the lakes to higher levels than at any time since records have been kept. The 1838 period of high water began in that year and continued until 1840, after which the lake levels subsided to normal conditions. There is no reason to suppose that the present extreme high-water conditions will continue longer than

FIG. 2. VIEW OF UPPER RAPIDS, at the head of which is the rock-rim determining the distribution of water, as it leaves the basin above (descent 55 feet). This rock-rim also determines the level of the Upper Lakes.

on previous occasions, although I am aware of a statement by an engineer holding a distinguished position, to the effect that we do not know that the levels are going to recede. This appears to have been said for politic reasons, as the pressure to further divert the water is very strong.

There is much popular curiosity as to the cause of the high water, which is not wholly explained by the rainfall. Mr. E. S. Wheeler, of the U. S. Lake Survey, found in his elaborate study of the physics of the rivers that changes could be produced by ice jams holding back the discharge and raising the lake so high that upon the melting of the snows together with spring rains, the waters could not run out sufficiently fast during the ensuing season, so as to bring the levels of the lakes to their normal condition. These effects could accumulate during succeeding seasons so that the extraordinary stages might last not merely one year, but for several years.

From the foregoing, it must be apparent to any one that no opinions can be formed on power diversion which ignore the fluctuations of lake levels, for as these vary, so do the discharges of the rivers. The mean discharge of the Niagara River for 1901, a year of very low water, was 14,000 cubic feet per second below that of the mean level from 1891 to 1905. This was after the abstraction of a certain quantity of water, the exact amount of which is unknown to me, but probably not reaching 10,000 cubic feet per second. The mean discharge during 1907 reached 15,000 cubic feet per second above the average of the fifteen years mentioned; this being after the artificial abstraction of nearly 18,000 cubic feet per second. Thus the entire diversion of the Niagara waters has been not only concealed by the extraordinary stages of the river, but a further quantity could be withdrawn without any apparent effect upon the falls. The increasing discharge of Lake Erie, during this year, reached the maximum on April 27, when it rose to 60,000 cubic feet per second above the average of the fifteen years mentioned, besides which the diversion was probably nearly 18,000 cubic feet; so that the full use of the franchises of the present power companies would not impair Niagara Falls to-day, but this condition can not last, and it is unfortunate that it should occur at this time, for the sake of those who are interested in the preservation of the falls, as well as in the navigation of the lakes.

In studying the physics of Niagara River, individual months or single years can not be adopted as standards, but I have found that satisfactory results can be obtained by taking groups of five-year periods. Perhaps some other arrangement might prove better. This has resulted in my adopting as standards of lake levels and river discharges, the means of the fifteen years succeeding the lowering of the lake outlets, and the present temporary high water will doubtless

adjust itself in the general averages, as on previous occasions, so that we must consider the effects of power diversion under normal conditions. As stated before, when the corrections are made in the discharge calculations prior to 1891, they fall into harmony with those of more recent date. These corrections do not appear in the work of any other writer, but I find them necessary, in order to explain incongruities, and to arrive at a satisfactory understanding of the effects of power diversion on Niagara Falls and the Great Lakes. Under these conditions, let us examine the physics of Niagara River.

10. *Basin above the Rapids.*—Above Niagara Falls are the Upper Rapids, descending fifty-five feet to the brink of the cataract. These begin as the water passes over a rim of rock (see figures 2, 3, 5) which crosses the river at the head of Goat Island. This is the "critical point," not merely in the distribution of water over the falls, but also in the level of Lake Erie, and indirectly of Lakes Huron and Michigan. Except at one small part near the Canadian side, the rock rim is from two to five feet higher than the rock-floor of the shallowest part of the river, about seventeen miles above the head of the Upper Rapids, and two miles below the outlet of Lake Erie. Throughout this distance the river crosses a depression, refilled with drift, so that here the channel itself was easily excavated to a much greater depth than across the two rock barriers mentioned, thus forming, *de facto,* a basin beginning with the narrows at the Buffalo Water Works, which are only 1,850 feet across, soon widening out into the broad stretches of the river on either side of Grand Island, below which they unite into another basin, over a mile wide, above Goat Island and its associated rock rim. This from its greater height than at the Water Works, constitutes the true rim of the Erie basin. The slope of the river between these points is due to the narrowness of the outlet of the lake, where the waters are so piled up that they have a velocity reaching to eight miles an hour, while in the basin above Goat Island the current is reduced, and is there from two to four miles an hour. The descent of the river from the lake to the rock rim at the Upper Rapids is about twelve feet.

11. *Depth of Water on the Rim of Upper Rapids.*—At mean stages, the average depth of the water in the American channel, as it begins to flow past Goat Island, is less than three feet, with a maximum of 4.5 feet. In the Canadian channel, for some 400 or 500 feet from Goat Island, under present ordinary conditions, the water is only from half a foot to one foot in depth, then for another stretch it increases to between two and three feet, beyond which the river shoals, so that in ordinary stages the water is seen to descend, not only in almost broken streams, but it is so shallow that the floats which have been sent down the river do not pass over the rock ledges, but are carried by the

dividing currents on either side. Thus for perhaps half of the river from the Goat Island side, I have estimated the mean depth of the water over the rock rim as not exceeding two feet. Indeed, much of it is not over a foot in depth. Nearer the Canadian side it increases to nine feet (see figures 3 and 5).

FIG. 3. PROFILE OF RIM OF FIRST CASCADE, with forebay of Ontario Power Company in foreground.

12. *Portion of Falls in Immediate Peril.*—As the river is so shallow over the rock rim on the Goat Island side of the main channel, it forms only a thin sheet of water on the eastern side of the Canadian or Horseshoe Falls, for a distance of 800 feet from the Goat Island end. Indeed, from the changes already effected, this sheet of water has been reduced in depth by sixteen inches, thus in many places exposing the shelf of rock over which the rapids are passing (figure 4). This portion of the falls I had considered as being in most immediate peril, even more so than the American Falls, but recent soundings, about the head of Goat Island, show that a rocky floor extends almost across to the main shore of New York, which in the future must divert to a large degree the supply of water from the American channel between the island and the shore. Accordingly, the American Falls are in equal danger with the eastern side of the Canadian cataract.

I hope that in this study of the physics of the river, the importance of this rim has been sufficiently emphasized; for any lowering of the water in the basin, will cause the draining of the higher parts of this rocky barrier, which extends nearly two thirds of the breadth of the

FIG. 4. EASTERN SIDE OF FALLS BEING DRAINED. Power House in the background is situated in the park on the Canadian side.

channel from Goat Island—thus affecting most the eastern side of the falls. If it were broken through, as it will be in the distant future by the recession of the falls, the water in the basin would be immediately lowered, and the Upper Rapids would reappear as a cataract just below the Buffalo Water Works, where the rock-floor is now seventeen feet below the surface of the river, while at a mile and a quarter farther down the drift has already been excavated to a depth of fifty-three feet.

13. *Artifical Openings now made in the Basin.*—It is immaterial whether the artificial enlargement of the orifice to the basin be made across the rim, or from its sides, or from the bottom. One lateral channel has been made for a breadth of 100 feet, and a depth of fourteen feet below the surface of the basin. There is also a neighboring one of about equal proportions. These made channels consequently reach depths much below the general level of the rock rim. They constitute the intakes of the two power companies on the New York side, and were calculated to carry 14,500 cubic feet per second at low stages (see map, figure 5).

On the Canadian side, the Ontario Power Company has installed a peculiar structure at the end of the rock rim, above which the river has a depth of five or six feet. Just below, at the natural edge of the basin, they threw out a wall, forming a wing-dam of some eight acres. This wall was brought to about the height of the river floor above.

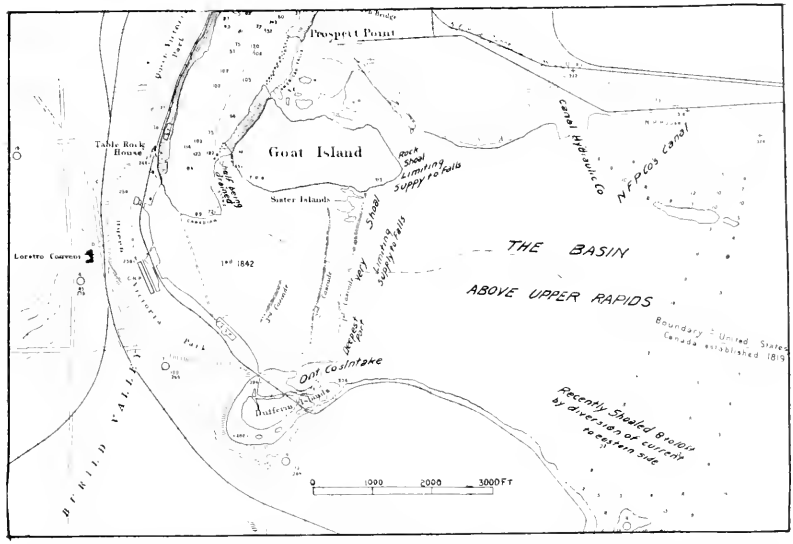

FIG. 5. MAP SHOWING THE POSITION OF THE FIRST CASCADE AND THE BASIN WHOSE LEVEL IS NOW BEING LOWERED BY THE POWER COMPANIES.

The effect of this is to extend forward the rock rim of the basin. Behind this wall, they removed the rock floor, in some places to a depth of seven feet, so that there is now a general depth in their dam of some six feet below the surface of the barrier, over which the water flows as if naturally. By taking the water from the bottom of the dam, while the river is still flowing over the top, the same effect is produced as if it were taken by a tunnel from any part of the floor of the basin of the Upper Rapids, and so increases the discharge from the basin.

The franchise of the Ontario Power Company is about 12,000 cubic feet per second, but works for only 4,000 cubic feet are completed. Their franchise has not been restricted as have been those of the New York Companies. The present amount of water due the New York Companies, as restricted under the Burton Act, is 14,500 cubic feet per second, although their franchises gave them 27,200 cubic feet per second.

These detailed accounts are given to show unequivocally, despite assertions to the contrary made to me by Mr. George C. Gibbons, chairman and legal representative of the Canadian section of the commission, that not only the older New York Companies, but also the Ontario Power Company (the other Canadian companies' works being below the rapids) must lower the water in the basin above the Upper Rapids. Indeed, Mr. Gibbons signs the report stating that if the water-supply were taken from Chippawa Creek, Lake Erie would be lowered, as the supply would come from back-water derived from Niagara River. This back-water would be flowing from the same basin which has been

described, consequently there can be no difference whatsoever from what point of the basin the water is diverted.

14. *Water taken from One Side of Basin affects the Other Side.*—That water can not be taken from one side of the basin without affecting the level on the other side is shown by the fact that, since the two New York companies began operations, the depth of the river, which is a mile across, near the mouth of Chippawa Creek, has been shoaled to the extent of eight or ten feet by the deposit of mud, owing to the slackened current in this part of the basin. So, also, when the power of the Ontario Company comes to be fully used, they will lower the water on the American Falls. Another proof of the diversion of water from the Canadian shore by the New York companies is the shoaling of the river just above the falls, where it was found necessary to throw a barrier to catch the water for the small local power plant, as the level of the river had sunk below the normal stage by the time one of the larger Canadian power plants was ready to begin operations.

15. *Power Diversion below the Upper Rapids.*—There are two other power plants situated in the Canadian Park, but below the Upper Rapids. Consequently, they lose much by their inferior head of water. This is a great gain, in that, taking the water some fifty feet below the basin, the overflow of the rim is not increased, so that this diversion produces no effect whatever on the lowering of the lake levels, or on the American Falls, or eastern side of the Canadian. These companies take the water from the deepest part of the channel, and consequently their effect is least apparent. Their aggregate allowance is about 20,000 cubic feet per second, or a net of 235,000 electric horse-power. However, much damage has been done to the western side of the falls, largely owing to the Canadian Niagara Power Company, on account of which the widening of the park has shortened the crest of the Horseshoe Falls by 415 feet, leaving in place of the sheet of water, a dark wall of rock stretching out into the gorge. It is strange that this impairment seems already to be almost forgotten except by a few lovers of the great cataract, but on looking at the Canadian Falls from the upper bridge the effect is to reduce the diameter apparently by one fourth (see figure 1).

16. *Water taken by Canals.*—The Welland and Erie canals divert less than 2,000 cubic feet per second, and, while the Chicago drainage canal takes at present scarcely more than 4,000, its rights extend to 10,000 and they want 14,000. The diversion by the Chicago canal of 10,000 cubic feet produces varying effects in the different basins, but it may be given at a lowering of the lakes by six inches, or some three inches for the basin at the Upper Rapids.

17. *Effect of Power Diversion on the Falls.*—We are now in a position to determine the effect of power diversion upon Niagara Falls and upon the navigation of the lakes. The water taken from below the

rim on the Canadian side may be omitted from the present discussion. This leaves a volume of 51,200 cubic feet per second, including that of the Chicago canal, conceded under the franchises, though temporarily limited to 44,500 cubic feet. At the beginning of 1908 there were approximately only 18,000 cubic feet per second in continuous use out of the amount affecting the basin (and this quantity may have been considerably reduced from the shutting down of some works), yet this diversion, together with the scour on the river, has lowered the water in the basin, immediately above, so that its level is sixteen inches lower than what it would have been, if no such changes had been effected. Half of the amount is due to the diversion of the water. It is this lowering of the water, just before passing the rim of the basin, at the head of the Upper Rapids, which is causing the lowering of the water on the falls, as shown in figure 4.

In confirmation of the above results, let it be stated that on June 14 a power company stopped its use of 8,000 cubic feet per second, and this caused the water in the basin to rise six inches (the diversion by the other companies and that of the Chicago canal was not arrested at the time). At the edge of the American Falls the water rose 1.2 inches.[2] At mean water much of the American Falls is scarcely more than six inches deep. With the lowering from extraordinarily high water to normal conditions, and the diversion increased in the future to 44,500 or 51,200 cubic feet per second, taken from above the Upper Rapids, the basin will be further lowered from twelve to sixteen inches or more, so that much of the rim of the basin will be exposed, and thus the flow of water will be largely cut off, not merely from the 800 feet on the eastern side of the Canadian Falls, thereby destroying that part, but also curtailing the water on the American Falls to half its present normal amount, which is only 5 per cent. of the total flow of both cataracts. This will be still further aggravated during years of low water, such as was 1901.

The preservation of the falls is now a question of inches. Under the conditions as set forth, the whole of the Horseshoe Falls will have shrunken from a crest line of 2,950 feet to 1,600 feet (including the curtailment on the Canadian side), and their diameter will have been reduced from 1,200 to 800 feet (see figure 6). They will then be

[2] It was telegraphed all over the United States that the rise was only a tenth of an inch, with congratulations of proof that no harm was being done to the falls. The term tenth-of-a-foot is one which would be used by engineers, but never in popular language, which depends upon inches. Hence the conclusion, jumped at, is partly explicable, especially by the promotion of power diversion at Niagara. But the change of depth above the Upper Rapids is that which determines the distribution and destruction of the falls. Besides, on the day of test, the discharge was 25,000 cubic feet and also nearly 18,000 more for power diversion above the normal discharge of Niagara River.

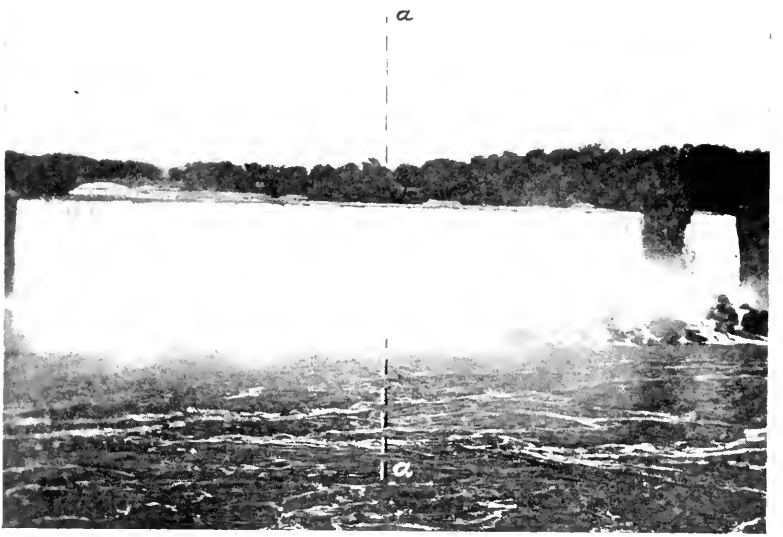

FIG. 6. NIAGARA FALLS, AMERICAN BRANCH. The half of falls on the right side of *aa* will be destroyed and that to the left damaged by full use of franchise amount.

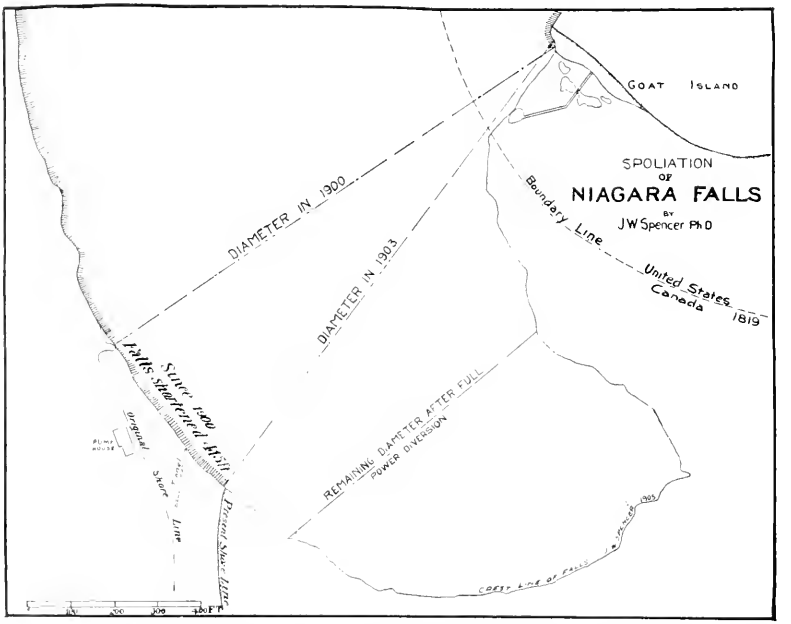

FIG. 7. MAP OF CREST LINE OF FALLS BEING SHORTENED FROM 2,950 FEET (IN 1900) TO 1,600 FEET UNDER FULL FRANCHISE DIVERSION; AND DIAMETER CURTAILED FROM 1,200 TO 800 FEET. The remaining falls will be entirely in Canadian territory.

entirely within Canadian territory, as the boundary line will become uncovered, leaving a narrow strip of rock between Goat Island and the great cataract. If the full franchise be used, the American Falls, which are 1,000 feet across, will have their southern half drained, as in figure 7, and will be further broken up into narrow sheets or strings of water.

Any attempt at restoring either the American or the eastern side of the Canadian Falls, by deepening the channels on that side of the river, would increase the velocity of the currents above and cause an extraordinary demand on Lake Erie, the result of which would be the lowering of its level at an enormous cost. The same physical changes would subsequently take place in the Huron outlet as a consequence of the lowering of the Erie level. The artificial deepening of the channel would also increase the scour, not merely of the Niagara River, but also the St. Clair channel, which lies in deposits of sand and clay.

Until such time as the use of the water shall become imperative, the preservation of the International Park and the falls is a very small bit of luxury or extravagance compared with the value and cost of great city parks, or even one of them, such as the Central Park of New York. But there is also a commercial side to this question. The yearly number of visitors to Niagara varies from 600,000 to 1,200,000 and the expenditure in transportation and at the falls is estimated as reaching sometimes $25,000,000 in a single year, giving pleasure and recreation to many people over the whole country. Are these considerations to be set aside for the gain of a few companies, or for political purposes?

A limited amount of power can be used without detriment to the scenic effects. Under the Burton act, the two New York companies are at present restricted to a developed capacity which is about half their franchises. The Ontario Company's franchise has not been restricted, although their present plant is developed to only one third its prospective size (figure 8). The full use of their allowance will affect the falls to an even greater extent than the Chicago canal, and bring into prominence the impending disasters, after the full use of the water at Chicago. The most strenuous endeavors are being made to extend the spoliation of the falls to its utmost limit, and recently the Ontario Company has sought permission to harness even the Whirlpool Rapids, which are fifty-one feet in height and only a little less imposing than the falls themselves. This company desires to obtain from twenty to twenty-five per cent. of the flow of the river, or nearly 400,000 gross horse-power, besides the privilege of disfiguring the gorge by their structures, such as the one already placed below the falls, though this at present is only one third of its prospective size, as shown in figure 8. There are two other great power houses in the Canadian Park. Those

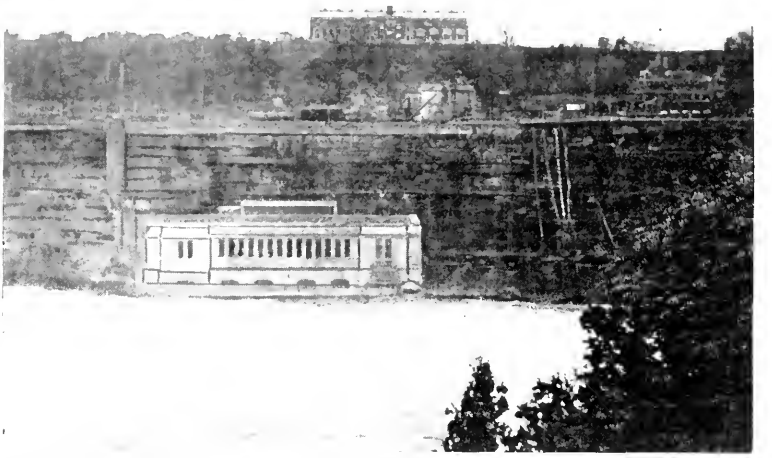

FIG. 8. ONTARIO COMPANY'S POWER HOUSE (270 FEET LONG) IMMEDIATELY BELOW THE FALLS IN THE CANADIAN PARK. This is only a third of the proposed length; even at present it is a most striking obstruction of the gorge, as seen from the New York side.

on the New York side are not in the park and can not be seen from the falls, but the eastern banks of the river below the park are crowded with works.

18. *Effects on Navigation.*—The canals and harbors are much shallower than they used to be. Several inches of this are due to the power diversion, which, however, is not at present seen, owing to very high water. The lowering of the level of the basin above the Upper Rapids, increasing the slope of the river, and consequently the velocity of the current, also lowers the level of the lake above. An increased discharge of 22,000 cubic feet per second lowers Lake Erie by one foot. On the large steamers in the carrying trade, each inch of draft represents a return of $100 in extra freight receipts. The canals and harbors should not be reduced in depth by power diversions at a time when there is a clamor for deeper channels. The impairing of navigation, under conditions as shown above, threatens to reach two, or even two and a half feet. Under the estimate made for the American Section of the International Commission, the cost of repairing the damage caused by the Chicago drainage canal was found to exceed $12,000,000, so that the total costs to both countries on account of power diversion promises to reach twenty-five millions of dollars or more. Are the power companies willing to pay for their share of this costly franchise, and for the loss owing to the diminished business going to and at the falls, which may reach $25,000,000 a year?

Unfortunately in the Province of Ontario it has become a political question, and there the government has adopted the Power Company which is causing the greatest amount of damage, although they could have obtained their supply from two other companies which are doing relatively little harm.

A prominent man at Niagara Falls, N. Y., has expressed himself as follows: "The subject of the diversion for power purposes is a burning question here, and a great number of unreliable and misleading statements have been made by interested parties to justify the diversion, stating that no damage will be done, and the work of Spencer" (referring to my recent book on the Falls of Niagara[3]) "is most timely in giving the results of a scientific examination of the whole problem, with the data on which the conclusions are based." In that work, the data are brought down only to January, 1906, but this contribution is based upon additional information extended to the present day, enabling me to give fuller and more precise results than in the original work.

The preservation of the falls now depends upon the governments at Washington and Ottawa. In the United States, apart from those interested in the diversion of the water, there is a wide-spread sentiment in favor of saving the scenic wonders of Niagara. But now another interest joins hands with this, which is economic and of great magnitude, namely, the protection of navigation. It is to be hoped that the national governments will so control the matter that this unique world-treasure will be preserved for all time.

At the present time the commission recommends the use of 28,500 cubic feet per second for the two restricted American power companies and for the Chicago drainage canal, while 36,000 cubic feet per second are conceded to Canada.

[3] "The Falls of Niagara," by J. W. Spencer, Geological Survey of Canada, 1907.